Aerodynamic Multisensor Electrometer

Atmospheric dust electrification is a highly probable phenomenon in the Martian atmosphere. To gain a more thorough understanding of the potential for electrostatic discharge of different materials on Mars, the Electromagnetic Physics Laboratory at KSC has developed an aerodynamic electrostatic multisensor that will measure the electrostatic and triboelectric properties of Martian atmospheric dust (Fig.1). This knowledge will provide necessary information for the design of landers, rovers, and habitation facilities in future missions to the planet.

The multiensor electrometer consists of an array of insulating materials with each material backed by a miniature electrometer. The instrument was designed to be exposed to mineral particles similar in composition to those in the Martian environment. To simulate a wind storm, mineral particles are propelled toward the instrument at speeds reaching 20 m/s. The overall sensor array has an aerodynamic configuration to minimize turbulent flow. The electrometer sensor uses a simple reference capacitor design similar to the one used on the Mars Environmental Compatibility Assessment (MECA) Electrometer (Fig. 2), a flight-ready instrument designed by JPL and KSC that included five sensors in a line array with a resolution of 5 million elementary charges. The probe consists of a field-sensor electrode that is enclosed by a guard electrode, which in turn is enclosed by an electrically grounded shield (Fig. 3). The probe is embedded in a cylinder to within 2.5 mm of the surface. The overall gain of the electronic circuit is 0.25 pC/mV. The current version of the instrument contains six sensors to measure the electric field induced by any net charge on six different insulator surfaces. The charge develops through frictional contact between the cylindrically shaped insulators and incident granular material.

Windborne dust particles were generated using a dust particle impeller that was developed at KSC to simulate a Martian dust storm in a vacuum chamber (Fig. 4). Constant wind speeds of 20 m/s have been measured with the dust impeller operating at gas pressures ranging from 5 mbar to 1 bar

Figure 5 shows the electrostatic response of polytetraflouroethylene (Teflon?), and fiberglass/epoxy to Martian simlant dust particles. The cylinders were exposed to windborne dust particles in separate experiments. Data were taken in a vacuum chamber containing a room temperature CO_2 atmosphere at 9 mbar. Other granular materials such as SiO_2, Fe_2O_3, and Al_2O_3, found by Viking and Pathfinder instruments to be major components of the Martian soil, have also been used in these experiments.

Contact: Dr. Carlos Calle YA-F2-T, (321) 867-3274, Carlos.Calle-1@ksc.nasa.gov

Participating Organizations: Florida Institute of Technology (Dr. J. Mantovani), YA-F2-T (E. Groop), Swales Aerospace (Dr. C. Buhler), and Dynacs Inc. (A. Nowicki).

FIGURE 1

Figure 1. Diagram of the prototype of the aerodynamic electrometer and its associated electronic housing is shown with sensor/guard probes embedded in six cylindrical insulators.

FIGURE 2

Figure 2. Circuit diagram for each one of the electrometer probes.

FIGURE 3

Figure 3. Probe design. Diagram of one of the electrostatic probes inside an aerodynamically shaped polymer. The Shield, Guard and Sensor electrodes are embedded below the surface of the windward face of the cylindrical insulator.

FIGURE 4

Figure 4. The KSC dust particle impeller operates at low pressures and is capable of propelling dust particles at atmospheric pressures and pressures as low as 7 mbar.

FIGURE 5

Figure 5. Martian soil simlant particles propelled to the aerodynamic electrometer with the probe embedded in Teflon? and Fiberglass cylinders.